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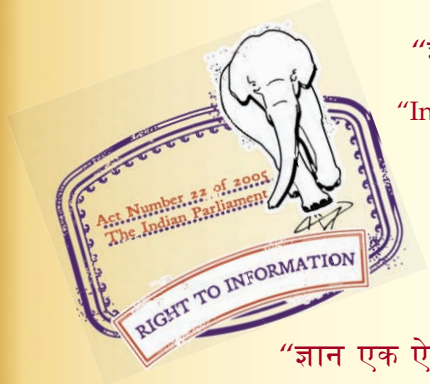
IS 10470 (1983): Specification for Air Cooled Heat Exchangers [MED 17: Chemical Engineering Plants and Related Equipment]



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"Knowledge is such a treasure which cannot be stolen"

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Indian Standard

SPECIFICATION FOR AIR COOLED HEAT EXCHANGERS

(Incorporating Amendment No. 1)

SECTION 1 GENERAL

1. Scope — Covers the design, construction, inspection and testing of air-cooled heat exchangers for application in the petroleum and general chemical industry.

2. Types and Nomenclature

2.1 *Types*

2.1.1 Air-cooled heat exchangers may be broadly classified into two types depending on draft provided:

a) *Forced draft* — Designed with tube bundles located on the discharge side of the fan (*see* Fig. 1), and

b) *Induced draft* — Designed with tube bundles located on the suction side of the fan (*see* Fig. 2).

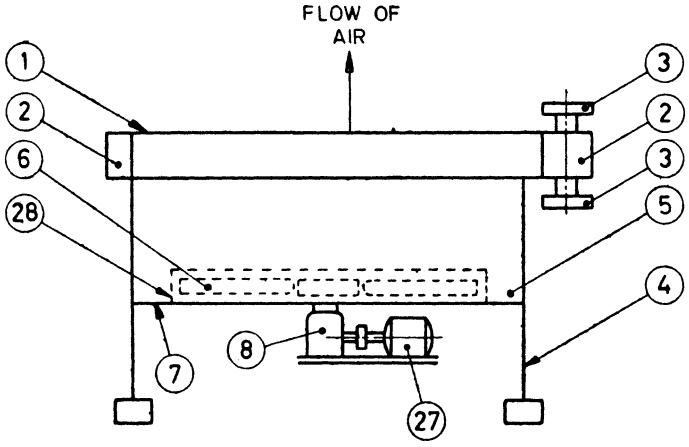

FIG. 1 FORCED DRAFT

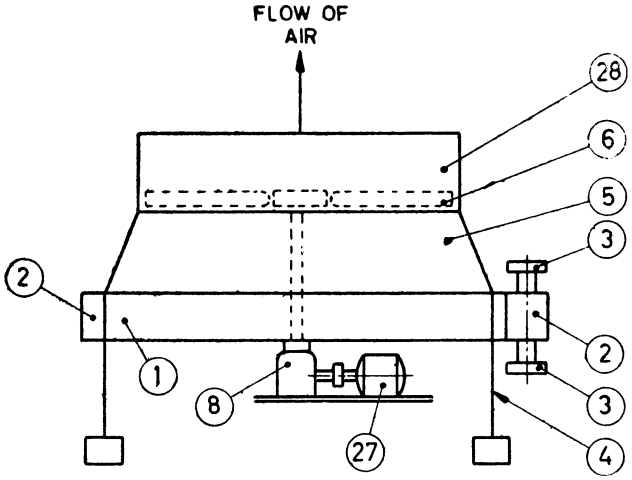

FIG. 2 INDUCED DRAFT

Adopted 27 January 1983 **Price Group 7**

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2.1.2 Air-cooled heat exchangers may also be classified into the following constructional types:

a) Removable bonnet headers (*see* Fig. 3),

b) Removable cover plate headers (*see* Fig. 4), and

c) Plug headers (*see* Fig. 5).

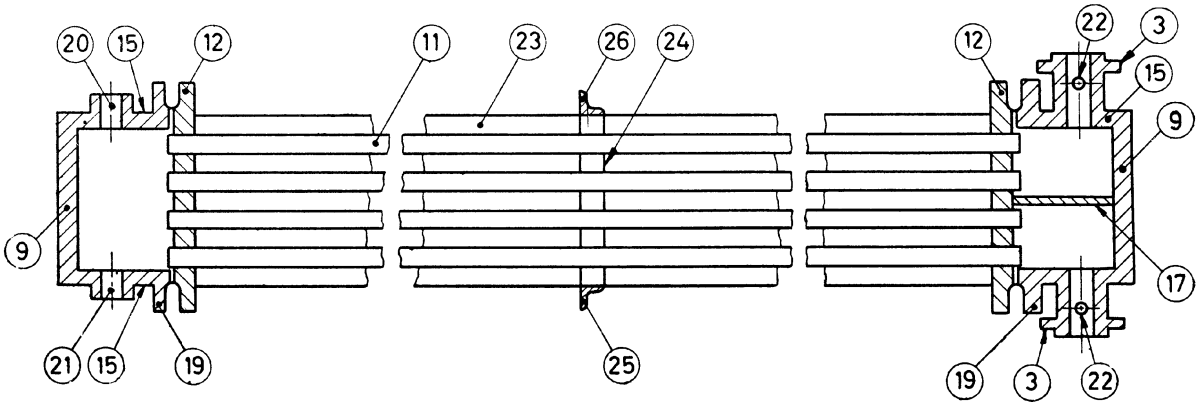


FIG. 3 TYPICAL CONSTRUCTION OF A TUBE BUNDLE WITH REMOVABLE-BONNET HEADERS

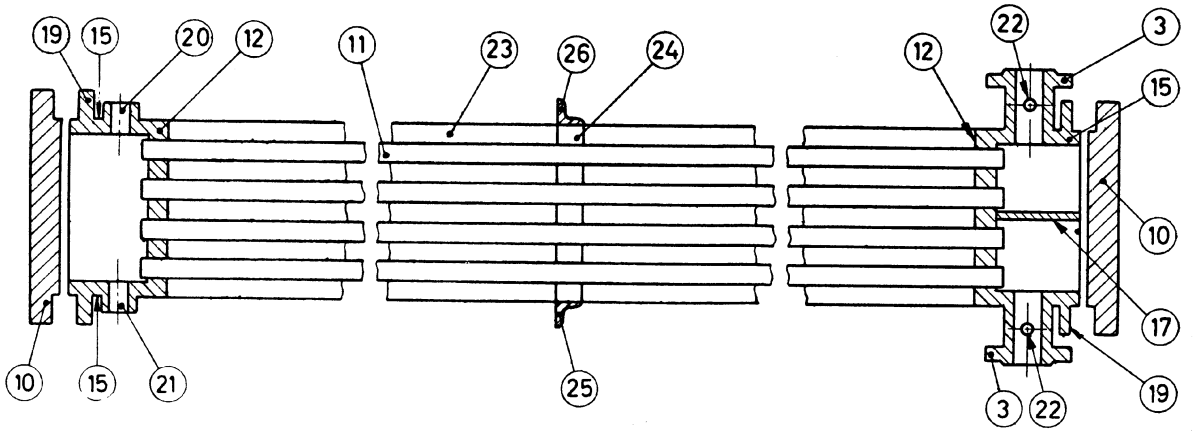


FIG. 4 TYPICAL CONSTRUCTION OF A TUBE BUNDLE WITH REMOVABLE-COVER-PLATE HEADERS

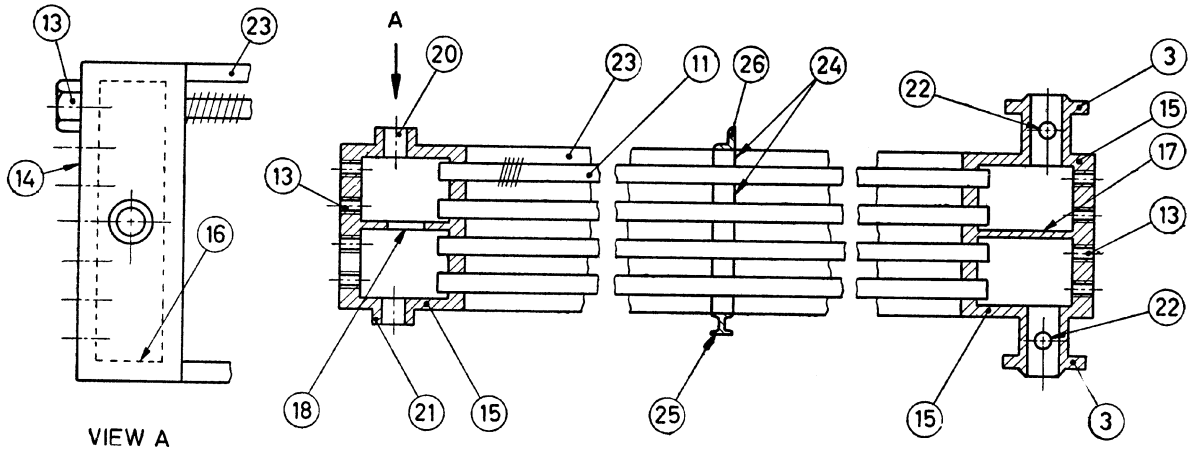


FIG. 5 TYPICAL CONSTRUCTLON OF A TUBE BUNDLE WITH PLUG HEADERS

2.2 *Nomenclature* — For the purpose of this specification, the different parts of an air-cooled heat exchanger shall be designated in accordance with the following table. These are numbered for identification in Fig. 1 to 5.

1. Tube bundle
2. Header
3. Nozzle
4. Supporting column
5. Plenum
6. Fan
7. Fan deck
8. Drive assembly
9. Removable bonnet
10. Removable cover plate
11. Tube
12. Tubesheet
13. Plug
14. Plugsheet
15. Top and bottom plates
16. Side plate
17. Pass partition
18. Stiffener
19. Flange
20. Vent connection
21. Drain connection
22. Instrument connection
23. Side frame
24. Tube support
25. Support beam
26. Tube keeper
27. Motor
28. Fan ring

3. Terminology — For the purpose of this standard, the following definitions shall apply.

3.1 *Design Pressure* — The pressure used in the design calculations for the purpose of determining the minimum thickness of the various component parts. Unless otherwise specified by the purchaser, it is obtained by adding 10 percent to the maximum working pressure or maximum working pressure plus 1.75 kg/cm^2, whichever is greater.

3.2 *Design Stress* — The maximum stress permitted for the materials of construction at the design temperature.

3.3 *Design Temperature* — The temperature used in the design of the exchanger for determining the minimum thickness of its component parts. It is taken as 25°C higher than the maximum temperature that any part of the exchanger is likely to attain in its course of operation. For mechanical components located above the tube bundles, the design temperatures shall be equal to maximum process inlet temperature, unless otherwise specified.

3.4 *Inspection Authority* — Duly authorized representative of the purchaser or any other component authority recognized by the statutory regulations to inspect the heat exchanger and determine its acceptability or otherwise on the basis of this specification.

3.5 *Tube Bundles* — Assembly of headers, tubes and frames.

3.6 *Section* — One or more tube bundles served by two or more fans complete with structure, plenum and all other attendant equipment (*see* Fig. 6).

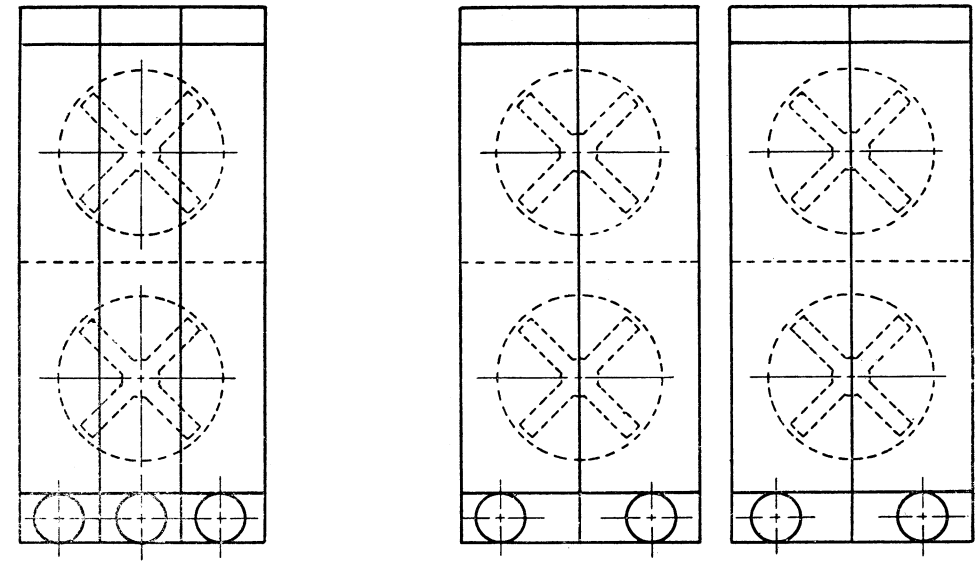


FIG. 6 TYPICAL SECTIONAL ARRANGEMENTS

3.7 *Unit* — One or more tube bundles in one or more sections for an individual service.

3.8 *Bank* — One or more sections consisting of one or more units mounted on one continuous structure.

3.9 *Bare Tube Surface* — Outside surface of bare tubes, based upon length measured between outside faces of header tube sheets.

3.10 *Finned Tube Surface* — Total outside surface exposed to air including fin surface, based upon length measured between outside faces of header tube sheets.

SECTION 2 MATERIALS AND DESIGN STRESS VALUES

4. Materials of Construction

4.1 *Headers and Tubes* — The materials for header plates, tubes, flanges, nozzle pipes, header covers and other pressure retaining parts shall be as per IS : 2825-1969 'Code for unfired pressure vessels'.

4.1.1 Cast iron shall not be used in any air cooled heat exchanger part which has a primary service pressure rating in excess of 10 kg/cm^2 or temperature in excess of 200°C or where failure would create a fire hazard or lethal service.

4.1.2 Pass-partition/stiffeners material shall be of pressure vessel quality.

4.1.3 Plugs for tube-access shall be compatible with header material except that cast iron shall not be used for plug materials.

4.1.4 Fin material shall be aluminium unless otherwise specified.

4.1.5 Rivet, screws or staple fasteners for securing fin ends shall be of stainless steel or aluminium material.

4.2 *Fan Blade Materials* — Fan blades shall be any of the following basic materials:

a) Aluminium or aluminium alloy, and

b) Reinforced plastic (phenolic or epoxy resin).

4.3 *Louvers Material* — Louvers material shall be aluminium.

4.3.1 Louver blade pivot pins shall be of austenitic stainless steel, aluminium or equivalent quality.

4.3.2 Louver bearings shall be filled with trifluoroethylene (TFE) material suitable for operating at maximum process inlet temperature.

4.4 *Structural Materials* — All structural quality steel shall be in accordance with IS : 226-1975 'Specification for structural steel (standard quality) (*fifth revision*)'.

4.4.1 The material for plenum chamber shall be in accordance with IS : 1079-1973 'Specification for hot rolled, carbon steel sheet and strip (*third revision*)'.

4.4.2 Structural support of steel such as side frames, plenum chambers, beams, etc, which are not accessible for maintenance shall be galvanized. If mill galvanized material is used, all cut, punched and weld edges shall be protected with a zinc rich coating.

4.4.3 Boltings for galvanized structural steel shall be galvanized.

5. Design Stress — The basis for establishing the design stress and the design stress values in tension for materials shall be in conformity with IS : 2825-1969.

SECTION 3 DESIGN AND CONSTRUCTION

6. General Design — All air cooled heat exchangers shall be designed and fabricated in accordance with IS : 2825-1969 and shall in addition take into account the requirements specified in this section.

7. Corrosion and Corrosion Allowance — The corrosion allowance shall be as specified except that no corrosion allowance shall be taken on tubes, gaskets and gasket contact surface.

7.1 If not specified a minimum of 3 mm corrosion allowance shall be provided for carbon steel components in contact with process fluid.

7.2 A thickness equal to the depth of the pass-partition groove may be considered as available for corrosion allowance on ground cover plates and tube sheet surfaces.

7.3 The corrosion allowance shall be provided on each side of pass-partition plates or stiffners.

8. Tubes

8.1 *Bare Tube* — The recommended minimum tube diameter is 25 mm.

8.1.1 The wall thickness for tubes 25 mm through 40 mm O. D. shall not be less than as specified hereunder:

Carbon steel	2.5 mm
Stainless steel	2.0 mm

8.1.2 Tubes may be furnished on either a minimum wall or an average wall basis provided that wall thickness is not less than that specified in **8.1.1**.

8.1.3 The total unfinned length of a finned tube between tube sheets after assembly shall not exceed 1½ times the thickness of one tubesheet.

8.1.4 Tubes with or without finned surface are acceptable.

8.1.5 The minimum tube wall thickness for the embedded fin tubes shall be measured from the bottom of the groove to the inside diameter of the tube.

8.2 *Fins* — Fins shall be applied on to the bare tubes in any of the following ways:

a) *Embedded* — Wrapped under tension and mechanically embedded in a groove 0.25 ± 0.05 mm deep spirally cut on the bare tube.

b) *Footed* — L-shaped fin wrapped under tension with tube fully covered by the feet between the fins. Fins ends shall be secured to prevent loosening or unraveling of the fins under design conditions.

c) *Integral* — Outer tube from which fins have been formed by extrusion, mechanically bonded to an inner tube.

d) Fins are bonded to the bare tube by hot dip galvanizing, brazing or by welding,

8.2.1 Minimum strip thickness for fins wrapped under tensions shall be 0.35 mm for fin heights not exceeding 12 mm and 0.40 mm for fin heights exceeding 12 mm.

8.3 *Tube Fixing*

8.3.1 *By expansion* — Tube shall be expanded for a length not less than 50 mm or tubesheet thickness minus 3 mm. whichever is smaller. In no case shall the expanded portion extend beyond the air-side face of the tubesheet.

8.3.1.1 The expanding procedure shall provide substantially uniform expansion throughout the expanded portion of the tube without sharp transition to the unexpanded portion.

8.3.1.2 The ends of tubes shall extend at least 2 mm and not more than 10 mm beyond the tubesheet.

8.3.2 *By welding* — Tube to tubesheet joints may be welded when both tubes and tubesheets or tubesheet facing are of suitable materials.

8.3.2.1 The welding procedure and testing techniques for welded tube-to-tubesheet joints shall be by agreement between the purchaser and the manufacturer.

9. Tubesheets

9.1 *Tubesheet Thickness* — The effective tubesheet thickness shall be the thickness measured at the bottom of the pass-partition groove minus the tubeside corrosion allowance in excess of the groove depth. This thickness does not include the thickness of the applied facing material but may includes thickness of cladding material in integrally clad plates and cladding deposited by welding.

9.1.1 The minimum nominal thickness of tubesheets shall be 16 mm plus corrosion allowance.

9.2 *Tube Hole in Tubesheet*

9.2.1 *Diameter and tolerances* — Tube holes in tubesheets shall be finished to the size and tolerances shown in Table 1. The special class fit shall be provided when specified by the purchaser.

TABLE 1 TUBE HOLE DIAMETERS AND TOLERANCES

All dimensions in millimetres.

Tube Outer Diameter (*d*)	Corresponding Tube Hole Diameter		Permissible Deviation on the Tube Hole Diameter			
	For Standard Fit	For Special Close Fit	For Standard Fit	For Special Close Fit	For 96 Percent of Tube Holes	For Remaining Tube Holes
(1)	(2)	(3)	(4)	(5)	(6)	(7)
25, 25.4	d + 0.30	d + 0.25	– 0.1	– 0.05	+ 0.05	+ 0.25
31.75,32	d + 0.37	d + 0.30	– 0.15	– 0.08	+ 0.08	+ 0.25
38.1, 40	d + 0.50	d + 0.40	– 0.2	– 0.10	+ 0.08	+ 0.25

9.2.2 *Tube hole finish* — The inside edges of tube holes shall be slightly chamfered after drilling and reaming to remove burrs and prevent cutting of the tubes.

9.2.3 *Tube hole grooving* — All tubesheet holes for expanded joints in tubesheets less than 25 mm thick shall be machined with one groove approximating 3 mm wide and 0.4 mm deep. A second groove shall be provided for tubesheet 25 mm thick or greater. Grooves shall be located at least 3 mm + corrosion allowance from process side face of the tube sheet and at least 6 mm from the air side face of the tubesheet.

10. Tube Supports — Tubes shall be supported to prevent sagging and meshing of tubes or deformation of fins and to maintain tube-pitch.

10.1 Tube supports shall be spaced not more than 1.8 metres from centre to centre.

10.2 A structural hold-down member shall be provided at each tube support. Hold-down members shall be attached to the side frames by bolting.

11. Headers and Header Covers

11.1 *General* — The designed nominal thickness minus corrosion allowance of various components shall not be less than those indicated below:

Components	*Minimum Thickness* (mm)
Top, bottom, side plate	9
Removable cover plate	22
Plug sheet	16
Partition plates	6

11.1.1 When fluid temperature differentials between the inlet to one tube pass and the outlet of the adjacent tube pass is greater than 110°C, split headers, U-tube construction, or other methods of restraint relief shall be employed.

11.1.2 Headers shall be designed to have the cross-sectional flow areas of each pass equal to at least 100 percent of the flow area in the corresponding tube pass.

11.1.3 All header welds subject to pressure (except as noted in **15.2**) shall be full penetration and full fusion. All header welds, other than nozzle-to-header weld, shall be double welded, joints, except in case of inaccessibility where single side-welded joints are acceptable provided full penetration is obtained.

11.1.4 Single-welded joints shall use MIG, TIG or shielded metal arc with Cellulose-coated electrodes for the root pass.

11.2 *Removable Cover Plate and Removable Bonnet Type Headers* — The cover plate header design shall permit removal of the cover without disturbing header piping connections.

11.2.1 The bonnet header design shall permit removal of the bonnet with minimum dismantling of header piping connections.

11.2.2 Bolted joints shall be designed with confined gaskets or unconfined full faced gaskets. Typical construction is shown in Fig. 7.

11.2.3 Cover plates, tubesheets and flanges shall be spot faced or back faced for nut seating.

11.2.4 Either jack-screws or 5 mm minimum clearance shall be provided at the cover periphery to facilitate dismantling.

11.2.5 The bolts shall be fully threaded.

11.2.6 The minimum nominal diameter of stud-bolts shall be M20.

11.2.7 Pass partition plates and stiffners shall be welded from both sides, full length, along the three edges.

11.2.8 The lugs shall be provided for lifting/handling of cover plate and for removable bonnet.

11.3 *Plug Type Header* — Plugged holes shall be provided opposite the ends of each tube for access.

11.3.1 The diameter of the plug holes shall be equal to the nominal outside diameter of the tube plus a minimum of 0.8 mm.

11.3.2 Gasket contact surfaces of plug holes shall be spot-faced. The edges of the facing shall be free of burrs.

11.3.3 plugs shall be of the shoulder type with straight threaded shanks.

11.3.4 Hollowed plugs are not permitted.

11.3.5 Plugs shall have hexagonal heads. The minimum dimension across the flats shall be at least equal to the plug shoulder diameter.

11.3.6 The pressure seal shall be maintained by means of a gasket between the flange of the plug and the plug sheet.

11.3.7 Plugs shall be long enough to fill the plug sheet threads with a tolerance of ± 1.5 mm.

11.3.8 For pass partition plate welding to header box, a full penetration attachment weld shall be used.

11.3.9 The design procedure for a typical rectangular header is shown in Appendix A.

11.3.10 For headers with corner radii, the minimum radius to avoid excessive discontinuity stresses shall be one third of the plate thickness with minimum 8 mm.

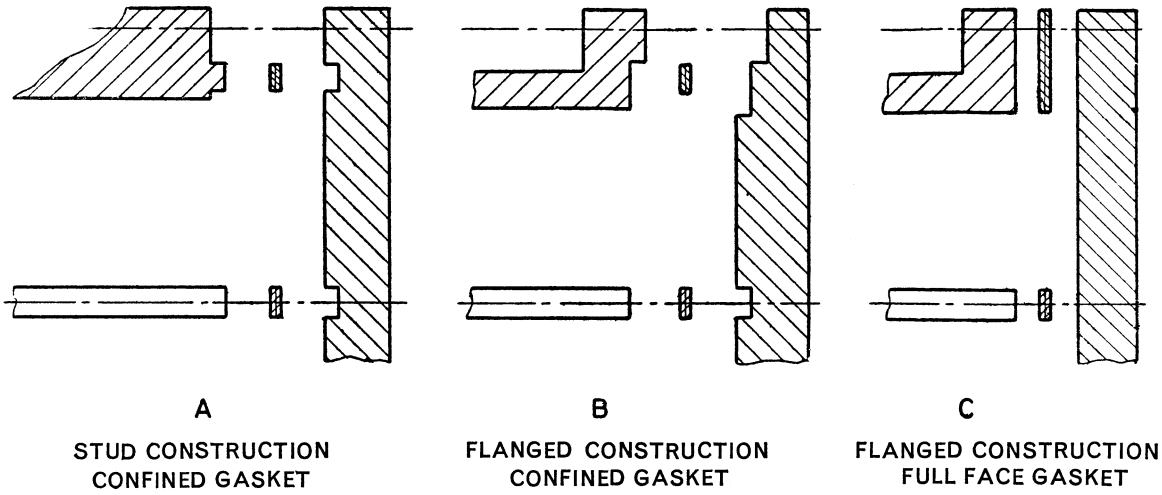


FIG. 7 TYPICAL CONFINED AND FULL-FACE GASKET JOINT DETAILS

12. Tube Bundle Assembly

12.1 *General Requirements* — Tube bundle shall be rigid and self-contained and shall be designed for handling as a complete assembly.

12.1.1 At least two lifting lugs shall be provided on each side of tube bundle frame.

12.1.2 Heating coils provided for protection against freeze-up shall be in a separate bundle and not part of the process tube bundle.

12.1.3 Provision for a minimum lateral movement for exchanger tube bundles of 6 mm in both directions or 13 mm in one direction shall be made.

12.1.4 Provision shall be made to accommodate thermal expansion of tubes.

12.1.5 Air seals shall be provided throughout the tube-bundle and unit to effectively minimize air leakage and by-passing. In general, any air gap that exceeds 5 mm in width and which results in by-passing of the heat transfer surface shall be considered excessive.

12.1.6 The minimum thickness of metal used for air seal construction shall be 3 mm within the bundle side frame and 2.0 mm outside the bundle side frame.

12.1.7 Bolts for removable air seals shall be at least 12 mm nominal diameter.

13. Nozzles and Branch Pipes — Nozzles 40 NB and above shall be flanged.

13.1 Nozzles and branch pipes should be strong enough to withstand the accidental loadings which may occur during transit and erection of the tube bundles. They shall also be strong enough to withstand reasonable loads from connecting pipes.

13.2 Vent and drain connections shall be provided at high and low points on each header. Header nozzles installed at high and low points may serve as vents and drains. Connections serving as vents and drains shall not extend into the header beyond the inside surface.

13.3 Suitable arrangement shall be provided for venting and draining of multi-pass headers.

13.4 All nozzles NB 80 and above shall be provided with a pressure gauge connection and nozzles NB 100 and above shall be provided with a thermo-well connection.

13.5 The pressure gauge connection shall be 29 mm size and NP 400 rating half-coupling.

13.6 The thermo-well connection shall be NB 40 flanged connection.

14. Gaskets — Metal jacketted or solid metal gaskets shall be used for all joints coming in contact with hydro-carbons and for all pressure exceeding 20 kg/cm^2 g.

14.1 Compressed asbestos fibre or other suitable gaskets can be used if the following conditions are satisfied:

a) Design pressure less than or equal to 20 kg/cm^2 g, and

b) Non-hydro-carbon service.

14.2 The width of the removable cover plate and bonnet gaskets shall be at least 13 mm. Pass partition rib of the gaskets shall have width equal to the pass partition plate thickness and it need not exceed 13 mm.

14.3 Tube access plug gaskets shall be of the solid metal or double metal jacketted type of the same general material classification as the plug.

14.4 Gaskets shall be in one continuous piece all round including pass partition rib.

14.5 Gaskets for use with cast iron flanges shall extend to the outside edge of the flanges.

14.6 Metal gasket material shall be softer by at least 15 BHN than the gasket contact surface.

15. Flanges for Header — Flanges may be cut from solid plate as an entire (one piece) or be welded in stripe.

15.1 Flanges on units with a design temperature 260°C or lower may be installed with partial-penetration double welding. The unfused area between the welds shall be vented to atmosphere by a hole approx 3 mm in diameter.

15.2 Flanges on units with a design temperature above 260°C shall be installed with full penetration welding.

15.3 The minimum thickness of flanges for header shall be 25 mm.

15.4 Cast iron flanges shall be flat faced for full faced gaskets.

16. Structural Supports — The supporting structures shall be designed, fabricated and erected according to IS : 800-1962 'Code of practice for use of structural steel in general building construction (*revised*)', if made of steel and according to IS : 456-1978 'Code of practice for plain and reinforced concrete (*third revision*)', if made of concrete.

16.1 Structural members shall be designed to minimize vibration. The maximum permissible amplitude of vibration shall be 0.15 mm peak-to-peak as measured on primary structural members and machinery mounts.

16.2 Verification of compliance to vibration limits shall be done by trial-run.

16.3 Structural members shall be designed to exclude field welding.

16.4 Tube bundles shall be removable without removing the platforms. For forced draft design, the bundles shall also be removable without separately supporting the fan or the plenum and without disturbing the structure or adjacent units.

17. Fan Assemblies

17.1 *Fans* — Two or more fans aligned in the direction of tube length shall be provided for each section.

17.1.1 Fans shall be of axial flow type.

17.1.2 Fans shall be sized so that area occupied by the fan is a minimum of 40 percent of the bundle face area served by that fan.

17.1.3 Fans shall be located so that the dispersion angle shall not exceed 45° at the bunldle centre lines as shown in Fig. 8.

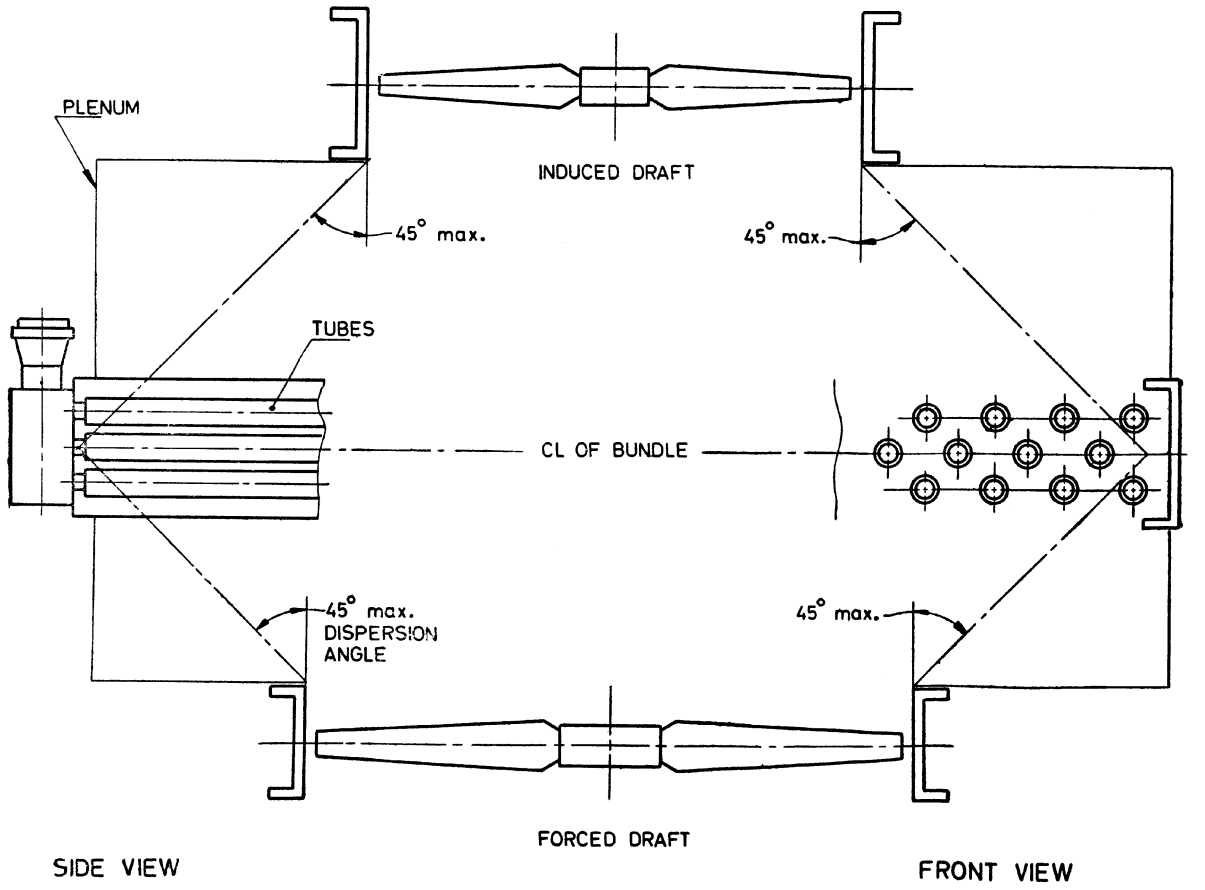


FIG. 8 FAN DISPERSION ANGLE

17.1.4 Fan tip speed shall not exceed 60 metres per second. However direct-driven fan tip speed shall not exceed 80 metres per second.

17.1.5 Radial clearance between the fan tip and the fan ring shall not exceed ½ percent of fan diameter with minimum 10 mm and maximum 19 mm.

17.1.6 Fan blades shall be dynamically balanced or moment-balanced against a master blade.

17.1.7 Fan hub shall be designed to prevent negative air flow.

17.1.8 Fan hub shall be dynamically balanced.

17.1.9 Except for direct-driven fans, individual fan blades are to be manually adjustable for varying blade pitch. Automatic control for varying blade pitch may be adopted depending upon service requirements.

17.1.10 The characteristic fan performance curve to be supplied by the fan supplier shall relate static pressure, rate of flow, blade pitch and fan input BHP for standard air conditions, dry air, dry bulb temperature 21°C, pressure 1.03 kg/cm^2 absolute and density 1.2 kg/m^3.

17.1.11 Fan selection at design conditions shall be such that at constant speed the fan is capable of performing by an increase in blade angle, a 10 percent increase in air flow with a corresponding pressure increase.

17.2 *Fan Shafts and Bearings* — Anti-friction shaft bearings shall have a nominal life of 50 000 hours at maximum load and speed.

17.2.1 The bearing design shall incorporate seals to prevent the loss of lubricant and entry of foreign materials.

17.2.2 Fan shafts shall have filleted key seats.

17.3 *Fan Guards* — Removable fan guards shall be provided on forced-draft units.

17.3.1 Flattened expanded metal for fan guards shall not exceed 50 mm nominal mesh size.

17.3.2 The minimum distance from the fan guard to the fan blade at its maximum operating pitch shall be 150 mm.

17.3.3 Gaps between guard and equipment shall not exceed 10 mm.

17.3.4 Minimum thickness of expanded metal mesh shall be 1.8 mm for 40 mm mesh and 2.8 mm for 50 mm mesh.

18. Plenums — Box-type plenums employing panel construction shall be designed to form an integral part of the structure.

18.1 Bank arrangements for field assembled units may be designed to employ common walls between adjacent plenums.

18.2 Plenums, including recirculating ducts above the tube bundle for over the side recirculation systems shall be partitioned to prevent recirculation of air from operating fans through non-operating fans.

18.3 Minimum thickness of steel sheet material used in the construction of plenums shall be 2.0 mm flat or 1.5 mm ribbed.

19. Access Facilities — Platforms for access to headers, for servicing drivers and the like shall be provided.

19.1 Platform shall have a minimum clear width of 800 mm.

19.2 Floor plate shall have raised pattern and a minimum thickness of 6 mm. Grating or expanded metal may be used if approved by the purchaser.

19.3 Approach ladders shall be provided for reaching the platform.

19.4 Ladders, railings, toe plates, safety cages and the like shall be of steel construction.

19.5 Safety cages shall be provided for ladders with a height of over 3.0 metres.

19.6 Chains with safety hooks or safety gates shall be provided across ladder openings at platform.

19.7 If pipe railings are not galvanized, they shall be sealed to prevent internal corrosion.

20. Drives and Drivers

20.1 *General* — Drives and drivers shall be suitable for at least 8 000 hours of un-interrupted operation.

20.1.1 Power transmissions shall have a rated horse power for continuous service at least equal to the rated brake horse power of the actual driver times the service factor.

20.1.2 Fan shaft and gear shaft couplings shall be of the non-lubricated type.

20.1.3 Exposed moving parts shall be provided with guards.

20.2 *Electric Motor Drivers* — For electric motor drivers, the rated brake horse power (BHP) available at the motor shaft shall be greater of the following:

$$\text{Driver rated BHP} = 1.85 \times \frac{\text{Fan BHP operating at specified minimum design ambient temperature with blade angle set for design dry bulb temperature}}{\text{Mech efficiency of drive}}$$

Driver rated BHP — 1.10 × Fan BHP operating at design dry bulb temperatures.

20.2.1 Electric motors shall be of the polyphase squirrel-cage induction type.

20.2.2 The type of motor enclosure shall be suitable for the area classification indicated by the client.

20.2.3 The motor shall have proper bearings and seals for operating in the specified position without loss of lubricant or intrusion of water. Drains shall be provided where necessary to avoid water accumulation.

20.2.4 The motor shall have proper bearings to withstand loads due to speed reducers with minimum normal life of 50 000 hours.

20.2.5 Direct motor drivers may be used for fans up to and including 1.5 m in diameter.

20.2.6 When a recirculation system is provided, motors shall be designed to operate at a temperature of not less than the recirculating air temperature, plus an allowance for the heat produced by the motor.

20.3 *Belt Drives* — Belt drives shall be conventional V-belt configuration, heavy duty, oil resistant and shall be of anti-static quality.

20.3.1 Belt drives shall be provided with belt tensioning means.

20.3.2 Top-mounted belt drive assemblies shall not be used.

20.3.3 V-belts may be either matched sets of single belt or a multiple-belt section formed by joining a matched set of single belts.

20.3.4 V-belts shall have a minimum service factor of 1.4 based on driver rated brake horse power.

20.3.5 V-belt drive assemblies suspended from the structure may be used with motor drivers rated up to and including 22 kW.

20.4 *Gear Drives* — Right-angle gear driver may be used with electric motors rated up to and including 22 kW but shall be used with all electric motors rated above 22 kW.

20.4.1 Gears shall be of the spiral bevel type. They shall have a minimum service factor of 2.

20.4.2 Top-mounted gear drives shall not be used.

20.4.3 Gears shall be provided with external gauge oil level indication visible from the operating platform.

20.4.4 The vender shall provide information concerning the expected gear lubrication oil temperature, viscosity, grade of oil provided initially, and other lubrication recommendations.

21. Vibration Switches — Vibration cutout switches shall be provided for fan driver units.

21.1 Vibration switches shall be of the manual externally re-set type not requiring disassembly of the switch for resetting and shall have sensitivity adjustment.

22. Louvers — Louver blade shall be at least 1.5 mm thick.

22.1 Louver frame shall be at least 4 mm thick.

22.2 Louvers shall be of the self-supporting type.

22.3 Un-supported louver blade length shall not exceed 1.7 metres.

22.4 Louver linkages shall be designed so that equal movement of all louvers blades result from a change of actuator position. Linkage shall be designed to transmit a minimum of 200 percent of the force required for full blade travel.

22.5 The gaps in the louver assembly shall be limited to:

a) Between louver blade and louver frame at header ends = 6 mm,

b) Between louver blade and louver frame at louver side = 3 mm, and

c) Between two blades in louvers fully closed position = 3 mm.

22.6 The minimum load for the design of louver blades shall be 200 kg/m^2 unless otherwise specified.

22.7 The minimum size of louver blade pivot pin shall be 10 mm at bearing location.

22.8 All louvers not automatically or otherwise remotely operated shall be provided with extensions or chains to permit manual operation from grade or platform except that extension or chains shall not be used where their length will exceed 6 metres. Handles for manual operators shall not project into walkways or access ways.

22.9 A locking device shall be provided for manual operators to maintain louver position. A means of indicating louver position "OPEN" or "CLOSED" shall be provided.

22.10 The louver characteristic performance curve shall relate the percent of air flow to the angle of the louver blade for the specific air cooled heat exchanger selection.

23. Inspection and Non-Destructive Testing

23.1 *Inspection* — The purchaser shall be offered all reasonable facilities to inspect at any reasonable time the fabrication at any stage and to reject any parts which do not comply with this specification (*see also* IS : 2825-1969).

23.1.1 No unit shall be released for despatch without approval of inspection.

23.2 *Non-destructive Testing* — Radiographic examination method and acceptance criteria shall be as per IS : 2825 and in addition shall comply with stipulations given below.

23.2.1 Where full radiography is called for, nozzle attachment welds that cannot be radiographed, shall be examined by magnetic particle and/or liquid penetrant method for crack detection. Examination shall apply to root pass, after back-chipping or flame gauging (where applicable), and to completed weld. Any defects shall be removed.

23.2.2 In case of spot radiography at least one spot radiograph shall be made of a longitudinal outside pressure weld and an end closure weld of each header.

23.2.3 Spot radiographs shall include each start, stop and burn-through of weld made by the automatic submerged arc welding process.

23.2.4 Spot radiographs shall be at least 250 mm long or full length where the weld is less than 250 mm long.

23.2.5 When set on connections are used, the edge of the hole in the plate to which the connections are attached shall be examined for laminations by means of magnetic particle or dye penetrant test. Indications found shall be cleared to sound metal and then back welded.

24. Testing

24.1 *General* — The testing procedure outlined below covers only the mechanical design and construction of the heat exchanger and does not include the process performance.

24.1.1 Each tube bundle shall be hydraulically tested at the manufacturer's works in accordance with **24.4**.

24.2 *Test Facilities* — The manufacturer shall supply free of charge the labour and appliances for testing of complete heat exchanger as may be carried out on his premises in accordance with the standard. In the absence of facilities at his works for making the prescribed tests the manufacturer shall bear the cost of carrying out the tests elsewhere.

24.3 *Gaskets for Test Equipment* — Heat exchangers shall be tested using the service gaskets so that the same leave the fabricator's shop in the 'as tested' condition.

24.4 *Hydraulic Testing* — Fresh water or any non-hazardous, non-corrosive liquid may be used by agreement between the purchaser and the fabricator for hydraulic testing. The testing temperature shall not be less than 15°C.

24.4.1 The test pressure shall be such that every point in the bundle it is at least equal to 1.3 times the design pressure multiplied by the ratio of safe stress value for the material of construction at the test temperature to the safe stress value at the design temperature.

24.4.2 The test pressure shall be maintained for at least one hour.

24.4.3 Paint or other coating shall not be applied over welds prior to the final hydrostatic test.

24.5 *Shop Trial Run* — The extent of shop run-in tests of the driver, the drive assembly and the fan of shop-assembled units shall be a matter of agreement between the purchaser and the vendor.

25. Marking — The manufacturer shall provide an austenitic stainless steel name plate fixed to any header at accessible location of each heat exchanger. The name plate shall be stamped with the following information:

a) Manufacturer's name;

b) Manufacturer's serial number and identification;

c) Design pressure, kg/cm^2 g;

d) Test pressure, kg/cm^2 g;

e) The letters SR if stress relieved;

f) The letters XR if completely radiographed; and

g) The number of this standard.

25.1 The following parts shall be stamped with the manufacturer's serial number:

a) Header,

b) Tubesheet flange of bonnet type headers, and

c) Cover-plate flange of cover plate type header.

25.2 The heat exchanger may also be marked with the ISI Certification Mark.

26. Preparation for Despatch — All liquids used for cleaning or testing shall be drained from units before despatch.

26.1 All external surfaces of carbon steel material not otherwise coated (except tube) shall be painted with removable rust preventive.

26.2 Surfaces to be painted shall be cleaned by wire brushing or similar means, to remove loose scale, dirt and other foreign material.

26.3 All flange faces of nozzles shall be protected to prevent damage, for example, by covering with wooden blank flanges. All threaded connections shall be plugged.

26.4 Machined surface exposed to atmosphere in transit and subsequent storage shall be protected with an easily removable rust preventive.

26.5 All parts shall be marked for identification and conditioned for transportation.

26.6 Each loose piece or assembly shall be properly protected to prevent damage during normal transportation and handling.

27. Certificate of Compliance — The fabricator shall supply to the purchaser a certificate stating that the exchanger complies in all respects with this Indian Standard and that it has passed the pressure test specified by this standard.

27.1 In cases where the purchaser requires a detailed certificate, including materials of construction, it shall be supplied.

APPENDIX A

(*Clause* 11.3.9)

RECTANGULAR HEADER DESIGN CALCULATION

To determine the thickness of headers of rectangular section with solid walls, it is necessary to consider the thickness required at the centre of the tubesheet, plugsheet, top plugrows, bottom plate, at all the centre-line and at the corners. The required thickness shall be the greatest value so determined.

The thickness is given by the following formula:

$$t = \frac{P\,X}{4SZE} + \sqrt{\frac{4\,PB}{SZ'E}}$$

where

t = thickness of header plate excluding corrosion allowance, in mm;

p = design pressure, in kgf/cm^2 g;

X = $\begin{cases} W \text{ — for thickness of tubesheets/plugsheets;} \\ h \text{ — for thickness of top/bottom plates;} \end{cases}$

S = design stress at design temperature, in kgf/cm^2;

Z = ligament efficiency referring to the membrane stresses

$$= 1 - \frac{d}{p};$$

Z' = ligament efficiency referring to the bending stresses

$$= 1 - \frac{d}{p} \text{ when } d < 0.3\,h \text{ or}$$

$$= 1 - 0.3\,h/p \text{ when } d \geq 0.3\,h;$$

B = moment coefficient as given below:

$$= \frac{1}{12}\,\frac{(h^3 + w^3)}{(h + w)} - \frac{X^2}{8} + \frac{C^2}{2};$$

h = internal height of header box in mm;

C = distance between centre of header to weld centre line/plug centre line/tube centre line/edge of plate, etc, where thickness is to be calculated, in mm;

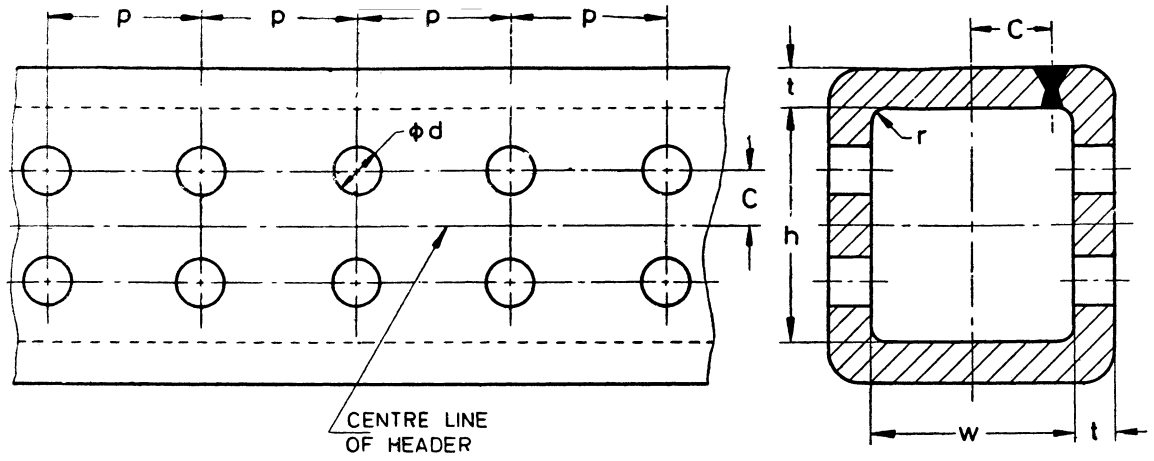
d = the diameter of tube holes/plug holes, in mm;

w = internal width of header box, in mm;

E = weld efficiency in accordance with IS : 2825. It shall be taken equal to 1.0 when calculating thickness at locations other than weld centre lines; and

p = horizontal tube-pitch, in mm.

Note — The value of Z and Z' shall be taken equal to 1 except for thickness of tubesheet/plugsheet at centre line of tube/plug row in which case it shall be defined as above.



All dimensions in corroded condition.

EXPLANATORY NOTE

Air cooled heat exchangers are rapidly gaining use in many branches of industry for services, such as cooling process streams and condensing steam. This specification lays down the essential requirements and gives guidance for the design end construction of such heat exchangers.

The design requirements given in this specification are based on those given in IS : 2825.

In the preparation of this standard, considerable assistance has been derived from the following:

API 661 : 1978 Air-cooled heat exchangers for general refinery services. American Petroleum Institute.

ISO/DIS 2694 Draft International Standard — Pressure vessels.

This edition 1.1 incorporates Amendment No. 1 (October 1985). Side bar indicates modification of the text as the result of incorporation of the amendment.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960 'Rules for rounding off numerical values (*revised*).' The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.